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(71) Applicant: ANALOG DEVICES, INCORPORATED [US/US]; One Technology Way, Norwood, MA 02062 (US).

(72) Inventor: O'MAHONY, Denis ; Analog Devices BV, Raheen Industrial Estates, Limerick (IE).

(74) Agent: BOLLINGER, Howard, M.; Parmelee, Bollinger & Bramblett, 460 Summer Street, Stamford, CT 06901 (US).

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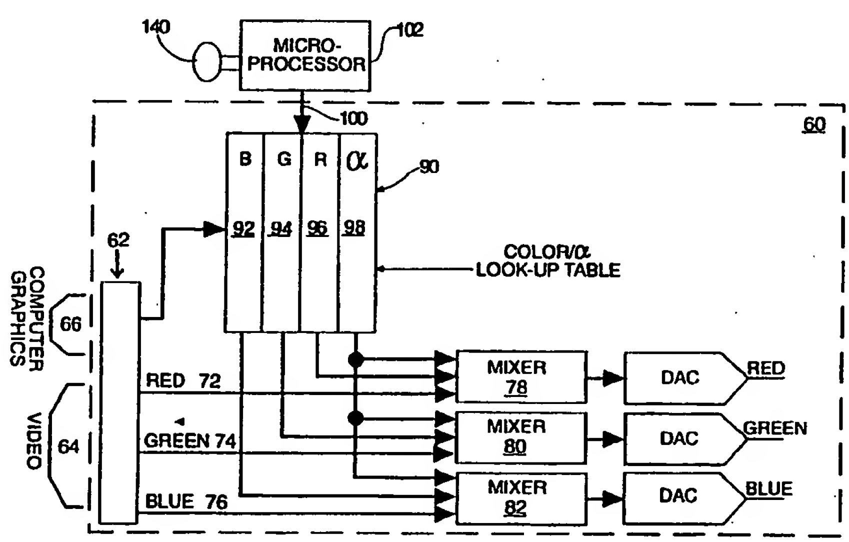
(54) Title: CRT DISPLAY APPARATUS WITH IMPROVED TECHNIQUES FOR BLENDING VIDEO SIGNALS WITH COMPUTER-GENERATED GRAPHIC SIGNALS



(57) Abstract

An integrated circuit (IC) chip (60) including respective mixers (78, 80, 82) for red, green and blue video and index-color signals, wherein the degree of mixing is controlled by respective alpha signals and the mixed signals are directed through DACs to a CRT to control its display, the IC chip (60) further including digital storage means serving as a look-up table (96) to develop said index-color signals in response to graphics signals applied thereto.

CRT DISPLAY APPARATUS WITH IMPROVED TECHNIQUES FOR BLENDING VIDEO SIGNALS WITH COMPUTER-GENERATED GRAPHIC SIGNALS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to color CRT display apparatus wherein digital color signals are converted to analog format for controlling the electron beam guns of the CRT. More particularly, this invention relates to such apparatus wherein the digital color signals comprise both video signals and index-color graphic signals which are blended or mixed together to jointly control the CRT display.

2. Description of the Prior Art

It is well known in the art of CRT display systems to overlay the basic "live video" display with computer-generated graphics so that both can be viewed together on the screen. In such systems, the video and graphic signals are blended together in controllable fashion, with the degree of blending being determined by a signal directed through a so-called "alpha" channel. Such prior art

systems commonly are arranged, as shown in the simplified block diagram of Figure 1, with separate frame buffers 20, 22 and 24 for storing and generating the video, graphics and alpha signals respectively.

The video frame buffer 20 includes red, green and blue frame stores which contain all of the color signal data for display of one complete live video frame on the associated CRT (not shown). These color frame stores typically are arranged as a large number of storage banks storing digital color intensity signals (e.g., 8-bits each) for all of the 3-color "pixels" to be painted on the CRT. The number of pixels may of course vary for different CRTs, but by way of example, the display may have 786,432 pixels, arranged as 1024 pixels in each horizontal line, and 768 lines in each frame. The video signals from the frame buffer 10 are used in a "true color" arrangement; that is, these signals are employed directly as color intensity signals for each of the red-green-blue colors, using techniques as shown for example in copending application Serial No. 665,309, filed by the applicant on March 6, 1991.

The graphics signals from the graphics buffer 22 are used in an "index-color" arrangement. That is, these signals are directed to a color look-up table (CLUT) 26 which stores red-green-blue digital color intensity signals at address locations selectable by the graphics signals. For any given graphics signal, three corresponding red-green-blue color signals are read out which together produce the desired color at the CRT. Such a color is sometimes referred to as a "pseudo-color". In a practical example, the graphics buffer 22 may produce 8-bit address bytes each identifying three CLUT locations storing respective 8-bit color intensity signals (red-green-blue) to be used to control the corresponding pixel.

The alpha buffer 24 may in such a practical example produce 8-bit bytes for setting the mix levels of the previously described video and graphics signals to determine the proportions of each in controlling the color of the CRT pixels.

The signals from the video and alpha frame buffer 20 and 24 together with the color signals from the CLUT 26 are directed to corresponding mixers 28, 30, 32 where the video and graphics color signals for each pixel are blended together in accordance with the value of the alpha signal for that pixel. These signals may be applied to the mixers through registers and the like (not shown) constructed in known fashion in this art, for example, as shown in applicant's above-identified copending application S/N 665,309.

Figure 2 shows schematically the internal arrangement of one type of mixer. It will be seen that the video signal A is applied to a multiplier 40 together with the selected alpha signal to produce a first output proportional to the product of these two signals. A second multiplier 42 receives the graphics signal B together with the complement of α (i.e., $1-\alpha$), and produces a second output proportional to the product of those two signals. The first and second outputs are then added together by a summation device 44 to produce the final blended digital output signal for the respective color (red, green or blue).

Other types of mixers can be used. For example, the video signals can first be differenced (A-B) with the resultant multiplied by alpha and then summed with the B signal. This is expressed as: α (A-B) + B. This requires only a single digital multiplier, and would be preferred because adders require less circuitry to implement than

multipliers. Referring again to Figure 1, the digital outputs from the mixers 28, 30, 32 are directed to respective DACs 50, 52, 54 which produce corresponding analog format signals for controlling the electron beam guns of the CRT. Such DACs are known in the art, and may for example be similar to those described in application Serial No. 649,433 filed on February 1, 1991 by Timothy Cummins.

Prior art systems as described above are capable of achieving the result of controllably blending video and graphics signals in accordance with an alpha-channel signal, as shown in the progressively faded text lines represented in Figure 3. However, the required control apparatus in such prior art systems is quite extensive and complicated, and thus is costly to make. Moreover, making changes in the nature of the displays, e.g., by altering the stored alpha information, involves a great deal of overhead effort including re-programming software which can be quite time-consuming and typically requires a high level of expertise. Accordingly, there is a need to provide simplified arrangements for achieving this blending function, and it is one object of the present invention to meet that need.

SUMMARY OF THE INVENTION

In a preferred embodiment of the invention to be described hereinbelow in detail, there is provided a CRT control system wherein the digital video signals are furnished by a video frame buffer as in the prior art. The digital graphics signals also are furnished by a frame buffer, somewhat as in the prior art. The disclosed arrangement in accordance with the invention needs no alpha frame buffer as provided in prior art systems.

In this embodiment, a single MOS integrated-circuit chip is provided for processing the digital color signals received from the external video and graphics frame buffers. This chip includes a color look-up table responsive to index-color address signals from the graphics frame buffer. This look-up table further includes a supplemental section containing alpha signals for associated color intensity signals stored at corresponding addresses in the look-up table. For each set of color intensity signals identified by an address from the graphics frame buffer, there will be an associated alpha number stored in the supplemental section of the look-up table. The alpha signal represented by this number will determine the degree of mixing of the associated index-color signals with the corresponding video color-intensity signals for the particular pixel of the CRT.

This arrangement provides a great deal of flexibility in its application to a variety of different needs. For example, the signals stored in the look-up table can readily be altered in the field, as by means of an external microprocessor supplying signals through an additional port. If desired, the alpha numbers for selected colors can be altered, while leaving the others unchanged. Various special effects can be developed such as gradients of mix level across the screen and captions or other text overlaid upon semi-transparent or "veiled" video. Such special effects can be initiated or controlled directly by the user, in many cases without requiring high-level expertise, or lengthy procedures. This can provide important benefits for television by allowing the viewer to make changes as he watches the screen.

The look-up table formed on the IC chip can for certain applications advantageously be divided (conceptually) into separate segments, all identical with respect to

the stored color signals, but differing as to the supplementally stored alpha signals. As one example, the table could be loaded with four identical sets of color signals (red, green, blue), with each set defining 64 different colors. These identical color signal sets could be stored in four memory segments respectively. Each segment also stores a corresponding alpha number which differs among the four segments; that is, there would be four different alpha numbers, one for each of the four sets of color signals. The address signal from the graphics buffer (e.g., having a total of 8-bits) could use two bits for identifying the alpha number, with the remaining six bits used for identifying the desired color of the 64 colors available. Thus, for any of the 64 selectable colors, any of four different degrees of blending of the graphic color signals with the live video signals can be selected.

Other objects, aspects and advantages of the invention will in part be pointed out in, and in part apparent from, the following detailed description of preferred embodiments of the invention, considered together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a block diagram illustrating a prior art system for controllably blending live video and computer-generated graphic signals;

FIGURE 2 shows a known mixer arrangement;

FIGURE 3 is a CRT presentation of a line of text duplicated four times to show four different levels of blending with a video background;

FIGURE 4 is a block diagram presentation of a preferred embodiment of the invention;

FIGURE 5 illustrates video and graphics frame buffers for use with the present invention;

FIGURE 6 is a pictorial presentation showing how the look-up table can be divided into segments containing duplicate color signals;

FIGURE 7 is a representation of the signals stored in the different segments shown in Figure 7;

FIGURE 8 illustrates graphic signal arrangements;

FIGURE 9 is a table showing how an 8-bit graphics signal can be divided up between color-identifying bits and alpha-identifying bits, and the available colors and blending levels with each combination; and

FIGURE 10 shows the difference in appearance of a CRT display using different blend arrangements in accordance with the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to Figure 4, one preferred embodiment of the invention comprises an IC chip 60 formed with connectors 62 to receive input signals 64, 66 from a video frame buffer 68 and a graphics frame buffer 70 as shown in Figure 5. The video signals 64 comprise the usual red-green-blue color-intensity signals, e.g., 8-bits each, which are directed through respective signal channels 72, 74, 76. These signal channels include appropriate registers and the like (not shown), and apply the signals to the inputs of respective mixers 78, 80, 82.

The computer-generated graphics signals 66 are directed as an address-identifying-signal to a look-up table 90 formed on the chip 60. This table basically

comprises an addressable memory having four sections 92, 94, 96, 98. The first three of these sections together serve as a color look-up table (CLUT) for an index-color system. For each address represented by one byte of the graphics signals (which may for example be 8-bits wide), three digital color-intensity signals are identified in the three CLUT sections 92, 94, 96 respectively. These three signals are transmitted to the inputs of the mixers 82, 80, 78 respectively and together represent a corresponding pseudo-color.

The fourth section 98 of the look-up table 90 is a supplemental section which stores alpha signals for each address identified by the graphics signals 66. That is, for each pseudo-color identified by a graphics signal, there will be a corresponding alpha signal stored in this fourth section. This alpha signal may for example have a width of 8-bits, representing a possible 256 levels of mixing for the video and graphics signals. The alpha signal located by the graphics address signal is directed to the inputs of all of the mixers 78, 80, 82. As in the prior art systems described with reference to Figure 2, each mixer produces a composite output digital signal (e.g., 8-bits) representing the projected intensity of the corresponding color (red, green, blue) of the pixel then being generated.

The alpha number to be developed for each address of the look-up table 90 can be pre-stored in accordance with a predetermined pattern programmed for a particular application. Advantageously, however, a second input port 100 may be provided to permit access to the signals stored in the look-up table, so that a device such as a microprocessor 102 can upon command change any of the signals stored in the table. Thus, any desired pattern of alpha signals can be selectively placed in the supplemental storage section.

Each of the stored sets of red-green-blue pseudo-color signals could if desired be assigned individual alpha signals from a wide range of available mix levels (256, for 8-bit alpha signals). As another example, one group of color signals (say, 250 colors) could be assigned individual different alpha numbers, while the remaining 6 locations in the table (assuming 8-bit addresses) could identify the same color but with different alpha numbers. The range of different implementations is very substantial, and provides a very high degree of flexibility, particularly considering that changes can be made quickly and easily, by software control using the external processor, without requiring any change in hardware.

In a further implementation of this invention, the graphics frame buffer 70 may be arranged as shown in Figure 5 so as to store both color-identifying bits 104 and alpha-identifying bits 106. For example, with a graphics buffer developing 8-bit graphics signals, six of the bits might be used to identify any one of 64 colors, while the remaining two bits might be used to identify any one of our alpha numbers. This approach permits a trade-off between the number of selectable colors and the number of selectable mix levels. That is, if having a large number of available colors is important for a particular application, this can be accommodated by using a limited number of alpha levels. Applications requiring a wider range of alpha levels can be accommodated by correspondingly limiting the number of available color gradations.

For such a split-signal arrangement, the look-up table 90 could (referring now to Figure 6) be supplied by the microprocessor 102 with four identical sets of color signals stored under software control in four separate memory segments 110, 112, 114, 116. Each of these segments would contain 64 sets of identical red-green-blue color

signals, thus providing 64 selectable colors. These memory segments could further be arranged, by the software controlled microprocessor 102, to store corresponding 8-bit alpha signals identified as $\alpha_1 - \alpha_4$. That is, each segment is provided with its own alpha number so that with the arrangement described, there will be four different alpha numbers, available for selection by the programmer of the graphics frame buffer. Since there are 64 addresses for each memory segment, there could be 64 identical alpha numbers stored for each segment, but different patterns could be adopted such as different alpha numbers in any one segment.

The color signals stored in the four segments are duplicative; that is, the 64 sets of color signals in each of the segments 110-116 are identical. For any one of the 64 selectable colors, the programmer of the graphics frame buffer can select any of four different α levels of mixing of those color signals with the corresponding video signals. However, it is clear that quite different patterns could be adopted, depending upon the application.

Figure 7 further explains this divided look-up table arrangement, and shows that any pseudo-color "A" can be selected from any of the four memory segments 110-116 together with any one of the four alpha signals $\alpha_1 - \alpha_4$ as determined by the graphics signal chosen. For example, color "A" might be selected by using an 8-bit graphics signal to identify address 20, which is in the bottom segment 110. This will produce three 8-bit color signals $R_A G_A B_A$ with a mixing level of α_1. Alternatively, the programmer may select for that pixel of the CRT the address 84, which is in the second segment 112. This address produces exactly the same color "A" (since 20 + 64 = 84). However, in this case α_2 will be applied to the corresponding mixers to create different levels of blending for the two sets of color signals.

Figure 8 provides further information about such an 8-bit graphics signal, showing how it can be used (a) so that all 8 bits (P0-P7) identify any one of 256 colors, or (b) so that 6 bits (P0-P5) identify any one of 64 colors, and two bits (α_x, α_y) identify any one of four alpha mixing levels (α_1 - α_4).

Figure 9 presents a table showing the trade-off options available in a signal arrangement as described with reference to Figure 8. For the case (a), where all 8 bits of the graphics signal are used to identify the color (see the top of the left-hand column), and no bits are used to identify alpha, the programmer can select any of 256 colors, but can identify only one blend level (as previously stored in the supplemental section 98 of the look-up table 90) regardless of the color selected. Alternatively, by devoting less than 8 bits of the graphics signal to identify the color and the remainder to identify alpha (as shown in the left-hand column in the entries below the number "8"), and supplying the look-up table 90 with duplicate sets of color signals, as described above, corresponding to the number of selectable alpha signals, various blending levels can be programmed for the color signals selected by the graphics frame buffer. At the extreme (bottom of the left-hand column), with all eight bits used to identify alpha, it will be seen that only one color is available to the programmer, but any of 256 blending levels can be selected.

Figure 10 shows how the appearance of a graphics character (the letter "A") can be controlled by using some of the graphics signal bits to make available more than one mix value. The right-hand portion 130 of the character shown illustrates the non-smooth edges which will result from using only one mix level per color. The left-hand portion 132 of the character illustrates the softening effect on the edges (producing the appearance of a more

nearly straight edge, rather than a jagged edge) that can be achieved by using some of the graphics signal bits to select different mix levels (in this case, 2 bits, to give 4 possible mix levels). Anti-aliasing thus can be performed with the disclosed system.

The disclosed system also facilitates the display of so-called "teletext" graphics. The signals carrying teletext graphics are transmitted to a television set during the CRT retrace time, i.e., while the electron beams are being returned from the lower right corner to the upper left corner of the screen. The teletext signals are decoded and used in the active part of the CRT display cycle together with the video signals.

Present day teletext transmissions do not carry alpha information, and do not permit the text display to be viewed as an overlay on the video display as a background. Instead, these systems require that a portion of the video be blanked out (made to appear black) in regions adjacent the text; commonly, a bottom section of the screen is blacked-out and the text is developed in that section. Thus, a large amount of the video display is lost. The present invention, however, makes it possible for the user of the television set to control the display so as to provide semi-transparent (or "veiled") video in the regions adjacent the text. Thus, essentially no video is entirely lost.

In current teletext systems, the coded information transmitted provides for only 8 colors, and thus requires only 3 bits. The color black (0,0,0) is transmitted for the spaces adjacent the text, and normally will simply block out any video in those spaces. With the present invention, each teletext color signal would in one arrangement be directed as an address to a color/alpha

look-up table which provides corresponding color signals for the CRT, together with alpha signals for controlling the mix of such color with the video signals. The transmitted signal for any color (such as black, 0, 0, 0) could be transposed by the look-up table to any other color (such as light green), and its mix with the video could be set at any desired level, e.g., 50%. The color/alpha look-up table in such an arrangement would be considerably simplified compared to that described above where up to 256 addresses are to be processed.

The television viewer could in such an alpha-controlled system be provided with an external adjustment for altering the stored alpha numbers (as by means of a microprocessor as previously described). This could be as simple as a manually-operable knob (pictorially illustrated at 140, Figure 4), such as is used for a volume control. Such a manual control could readily be arranged to activate the microprocessor to change the alpha numbers for all (or selected) colors through a specified range, thereby enabling the degree of "veiling" of the background video to be set to a level found most agreeable to the viewer.

Although preferred embodiments of the invention have been disclosed herein in detail, it is to be understood that this is for the purpose of illustrating the invention, and should not be construed as necessarily limiting the scope of the invention since it is apparent that many changes can be made by those skilled in the art while still practicing the invention claimed herein.

What is Claimed is:

1. In a CRT display system having means for producing digital video signals and digital index-color graphics signals;

and wherein said video and graphics signals are to be used for jointly controlling the display developed by the red-green-blue electron beam guns of a color CRT;

integrated-circuit chip means comprising:

mixer means having inputs for (a) digital video signals, (b) digital graphics signals and (c) digital alpha signals for controlling the degree of mix between the video and graphics signals for each color;

DAC means connected to the outputs of said mixer means to produce analog format signals for the electron beam guns of the CRT;

means for directing to said inputs of said mixer means respective red-green-blue video signals;

digital storage means serving as an index-color look-up table for red-green-blue digital signals stored for establishing digital color signals for said mixer means corresponding to addresses identified by said graphics signals;

means for directing the address-identified digital red-green-blue color signals to respective inputs of said mixer means;

said digital storage means further comprising means for storing digital alpha signals corresponding to said addresses respectively; and

means for directing the address-identified alpha signals to inputs of said mixer means for controlling the degree of mixing of said video and graphics signals.

2. Apparatus as in Claim 1, wherein said video and graphics signals are developed by respective frame buffers.

3. Apparatus as in Claim 2, wherein said graphics frame buffer stores digital index-color signals and alpha-identifying signals for such digital index-color color signals;

said integrated-circuit chip means further including means responsive to said alpha-identifying signals for selecting corresponding alpha numbers for the associated color signals from said look-up table.

4. Apparatus as in Claim 3, wherein said look-up table comprises a supplemental section storing alpha numbers;

said supplemental section being arranged to develop alpha signals corresponding to said alpha-identifying signals and to direct such alpha signals to said mixer means.

5. Apparatus as in Claim 4, wherein said look-up table is divided into segments each storing sets of index-color signals which are identical among said segments;

said segments further comprising supplemental storage sections storing alpha signals which differ among said segments.

6. Apparatus as in Claim 1, wherein said digital index-color graphics signals comprise bits for identifying alpha signals;

said look-up table comprising color-signal segments storing related sets of color signals;

said look-up table further comprising alpha-signal segments storing alpha signals to be identified by said bits of said graphics signals;

said alpha-signal segments being arranged to produce for each set of color signals from one of said color-signal segments a corresponding alpha-signal from an associated alpha-signal segment.

7. Apparatus as in Claim 6, wherein said color-signal segments store respective sets of color signals which are related by being identical so that the same colors can be selected from any one of said color-signal segments.

8. Apparatus as in Claim 7, wherein each of said color signal segments has a corresponding alpha-signal segment containing alpha numbers for each color in the associated color-signal segment.

9. Apparatus as in Claim 8, wherein the alpha signals in any one of said alpha-signal segments are identical but differ from segment to segment.

10. Apparatus as in Claim 6, wherein said one group of index-differing color signals differ and are assigned respective alpha signals, and a second group of index-color signals are identical but are assigned respective different alpha signals.

11. Apparatus as in Claim 1, including signal port means for supplying control signals to said digital storage means to up-date the data stored therein.

12. The method of controlling a CRT with true-color signals for a video display and index-color graphics signals for a graphics display to be overlayed on said video display, comprising the steps of:

directing said true-color signals to the input of mixer means;

directing said index-color signals to a color look-up table which develops corresponding sets of digital color signals;

directing said digital color signals to said input of said mixer means;

said mixer means serving to blend the true-color signals with the table-generated digital color signals to produce corresponding composite output signals;

controlling the degree of blending effected in said mixer means in accordance with alpha digital signals stored in a memory means associated with said look-up table; and

directing said composite output signals to DAC means to produce analog-format signals for the CRT.

13. The method of Claim 12, wherein said stored alpha signals are addressed by said graphics signals to provide that an alpha signal is developed for each color identified.

14. The method of Claim 13, wherein said graphics signals are developed to comprise a first signal portion for an index-color address and a second signal portion for a corresponding alpha address.

15. The method of Claim 12, including the step of altering the stored alpha signals in accordance with signals from means external to said integrated-circuit chip means.

16. The method of Claim 15, wherein said stored alpha signals are altered by signals from a microprocessor.

17. The method of Claim 16, including the step of altering the digital color signals in said look-up table by means of signals from said microprocessor.

18. The method of controlling a CRT with color signals for a video display and graphics signals for a graphics display to be overlayed on said video display, comprising the steps of:

directing said color signals to the input of mixer means;

directing said graphics signals to a color look-up table which develops corresponding sets of digital index-color signals;

directing said digital index-color signals to said mixer means;

said mixer means serving to blend the color signals with the table-generated digital index-color signals to produce corresponding composite output signals;

controlling the degree of blending effected in said mixer means in accordance with alpha signals; and

directing said composite output signals to DAC means to produce analog-format signals for the CRT.

19. The method of Claim 18, including the step of supplying said graphics signals from decoded teletext signals received during the retrace time of the CRT beams.

20. The method of Claim 19, wherein the degree of blending of the pixels of one section of the face of the CRT containing the teletext display provides for a veiled presentation of the display in that one section, whereby none of the video display is entirely lost.

21. The method of Claim 20, wherein the degree of blending is altered by an external control means.

22. The method of Claim 21, wherein the degree of blending is altered by a manually-operable control to provide for a presentation appearance as selected by the viewer.

23. The method of Claim 22, including the step of altering the degree of blending by data transmitted into a data storage device by a microprocessor controlled by said manually-operable control.

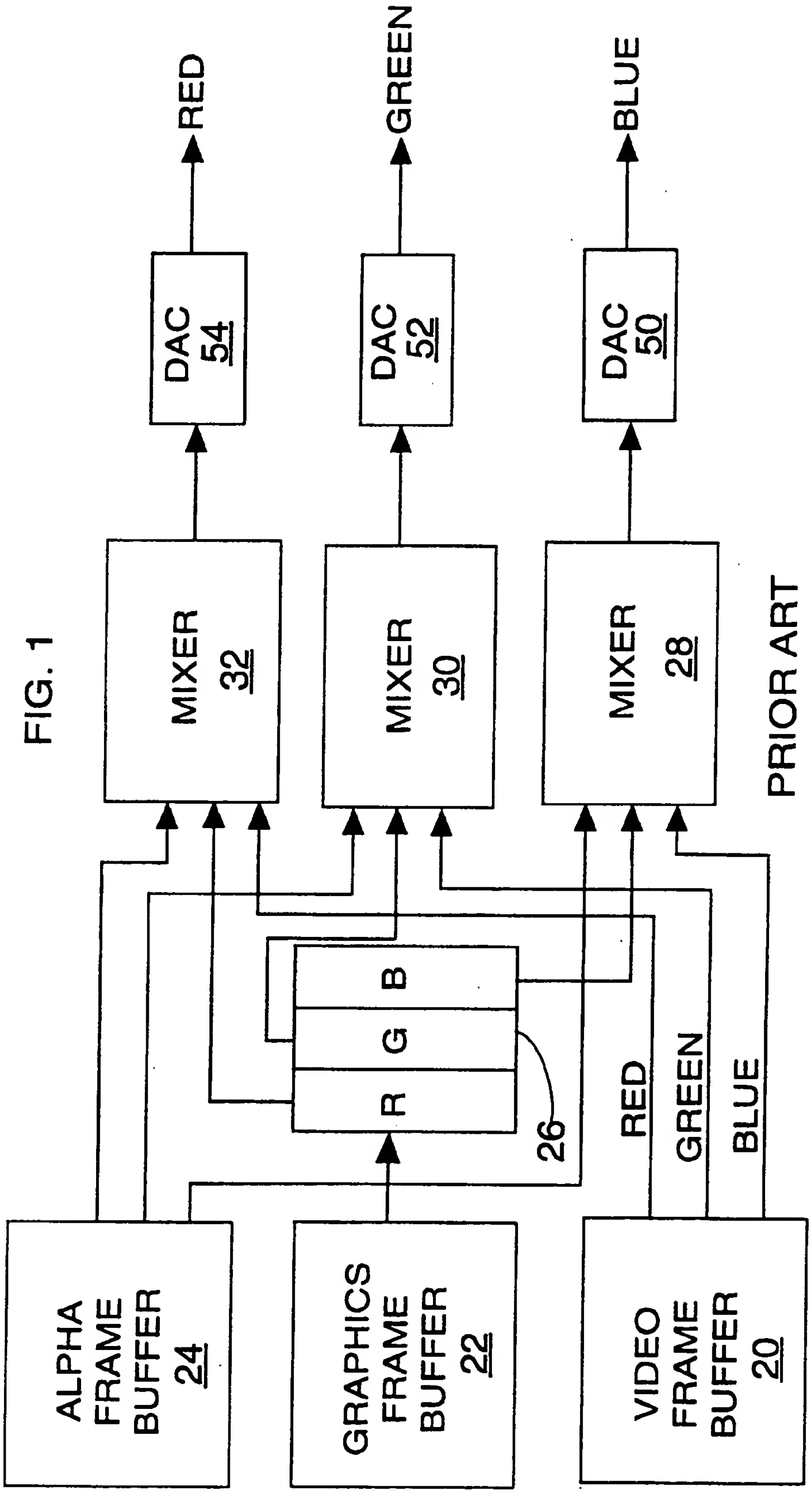


FIG. 1

PRIOR ART

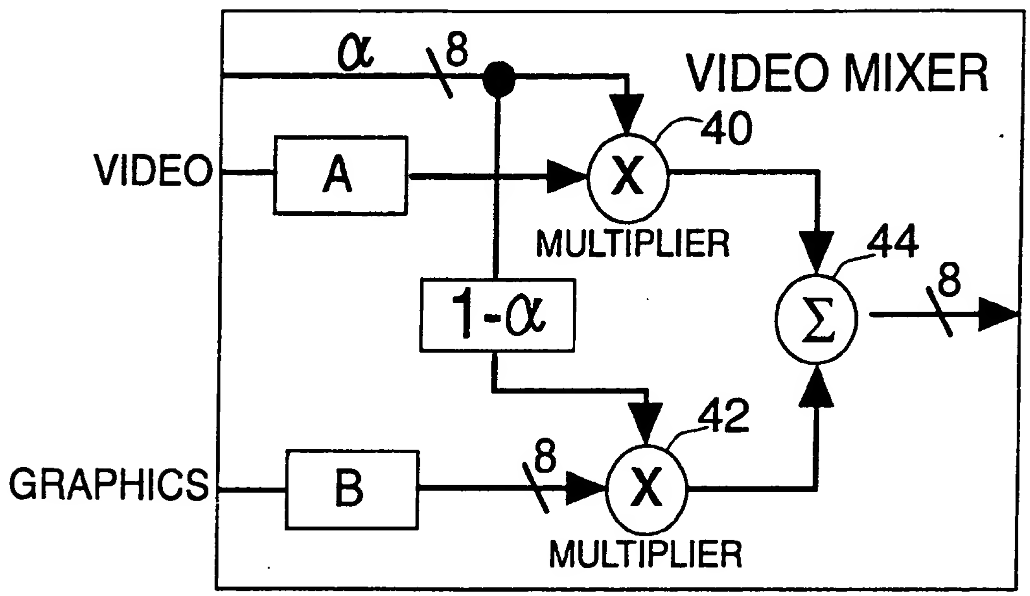


FIG. 2 PRIOR ART

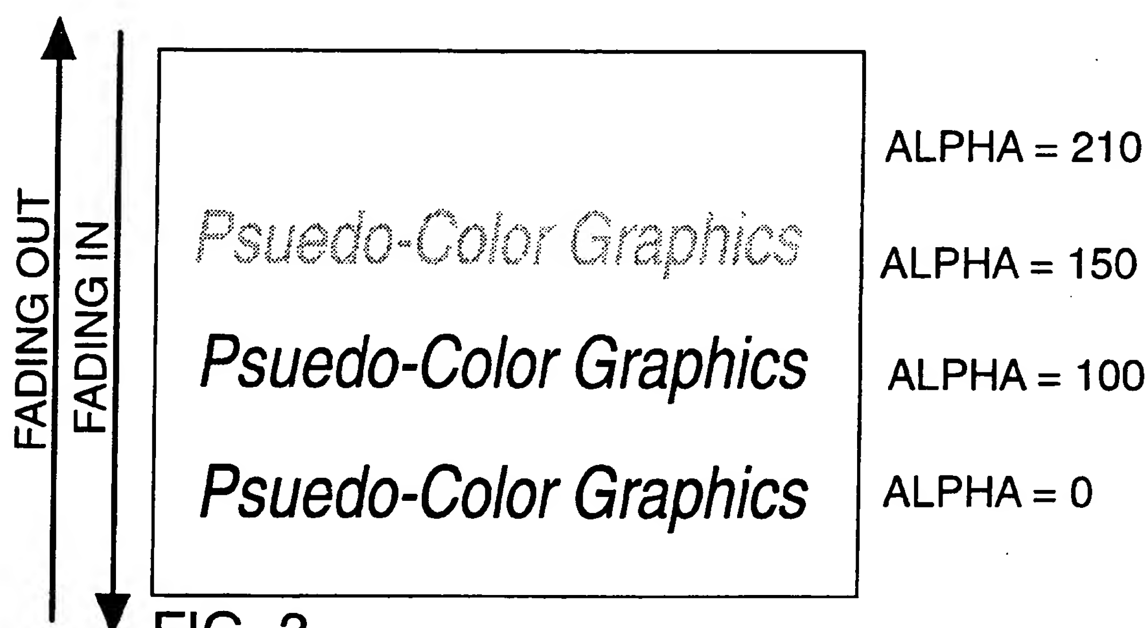


FIG. 3

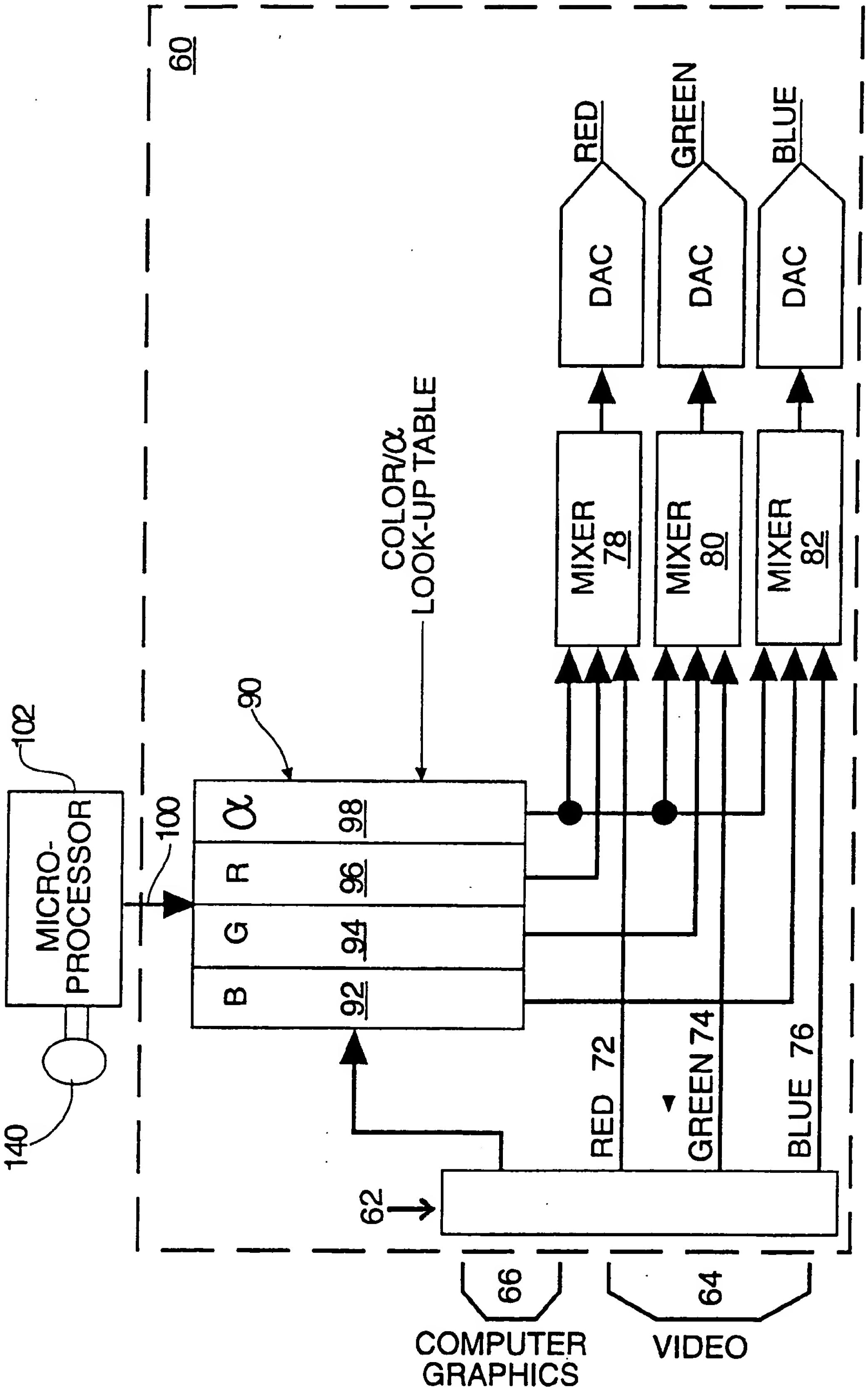

60
RED
GREEN
BLUE
DAC
DAC
DAC
COLOR/α
LOOK-UP TABLE
MIXER
78
MIXER
80
MIXER
82
102
MICRO-
PROCESSOR
90
100
α
98
R
96
G
94
B
92
140
RED 72
GREEN 74
BLUE 76
62
66
64
COMPUTER
GRAPHICS
VIDEO

FIG. 4

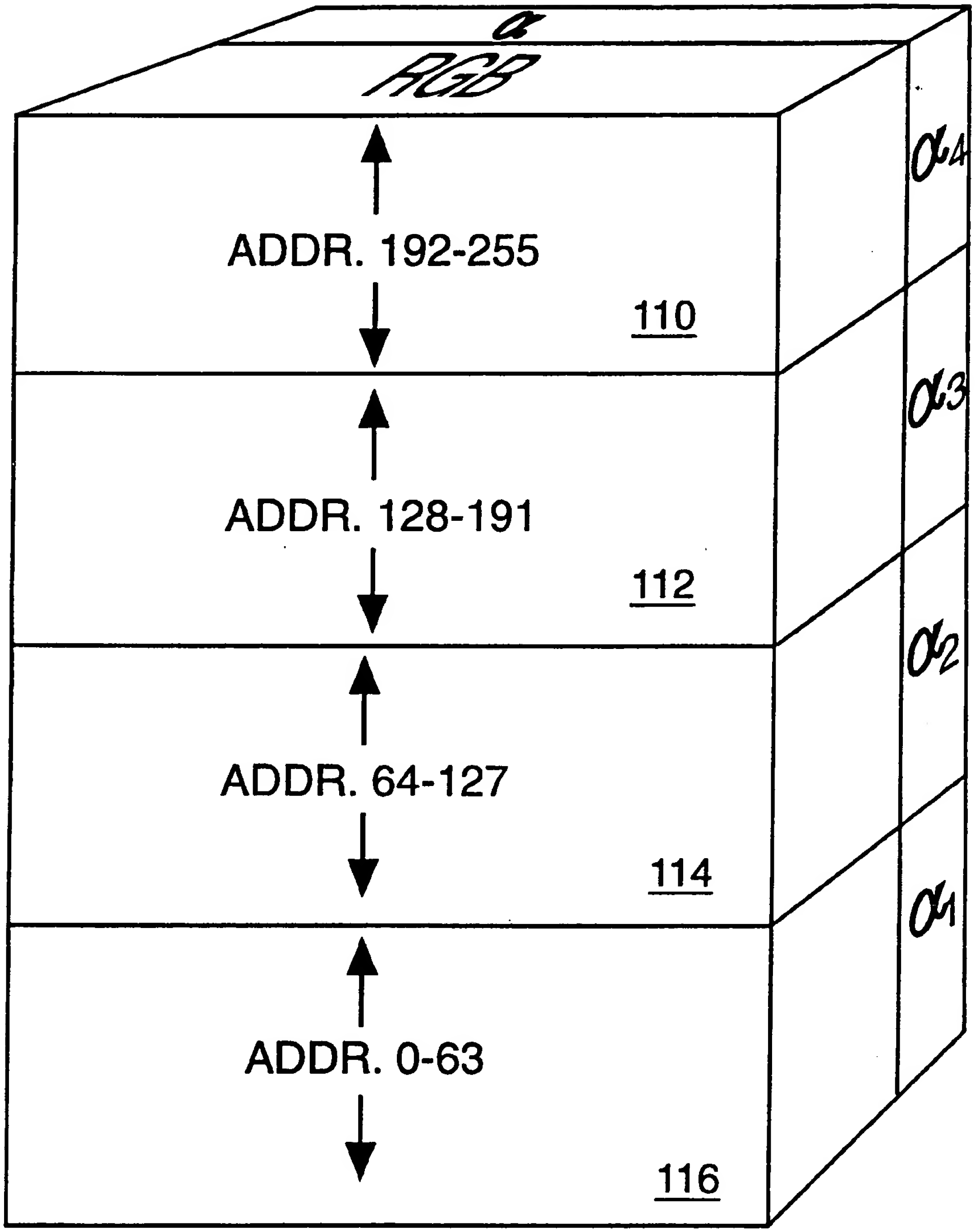
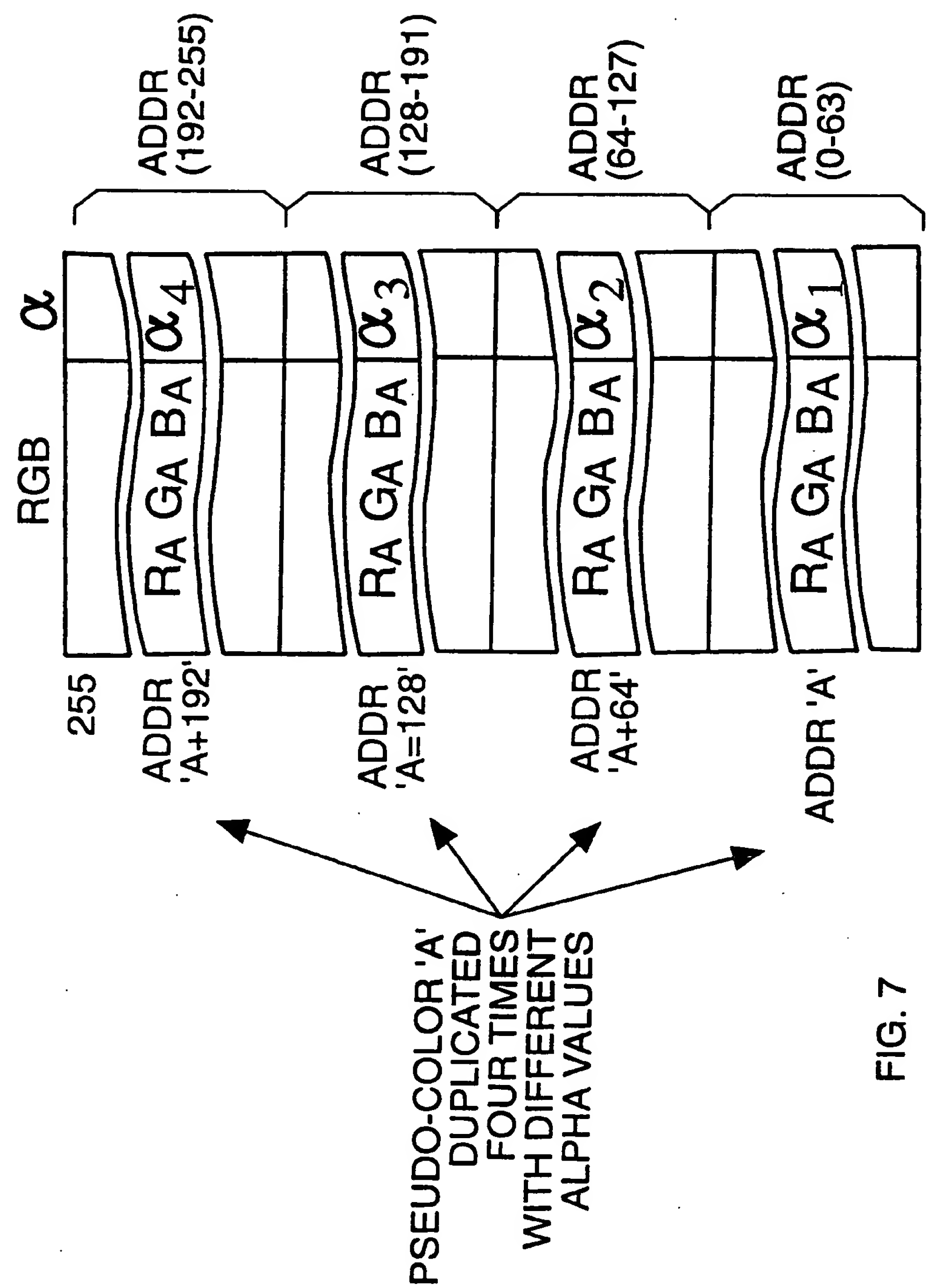

α
RGB
ADDR. 192-255
110
ADDR. 128-191
112
ADDR. 64-127
114
ADDR. 0-63
116
α4
α3
α2
α1

FIG. 6


RGB
α
255
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ADDR 'A=128'
ADDR 'A+64'
ADDR 'A'
RA GA BA α4
RA GA BA α3
RA GA BA α2
RA GA BA α1
ADDR (192-255)
ADDR (128-191)
ADDR (64-127)
ADDR (0-63)
PSEUDO-COLOR 'A' DUPLICATED FOUR TIMES WITH DIFFERENT ALPHA VALUES

FIG. 7

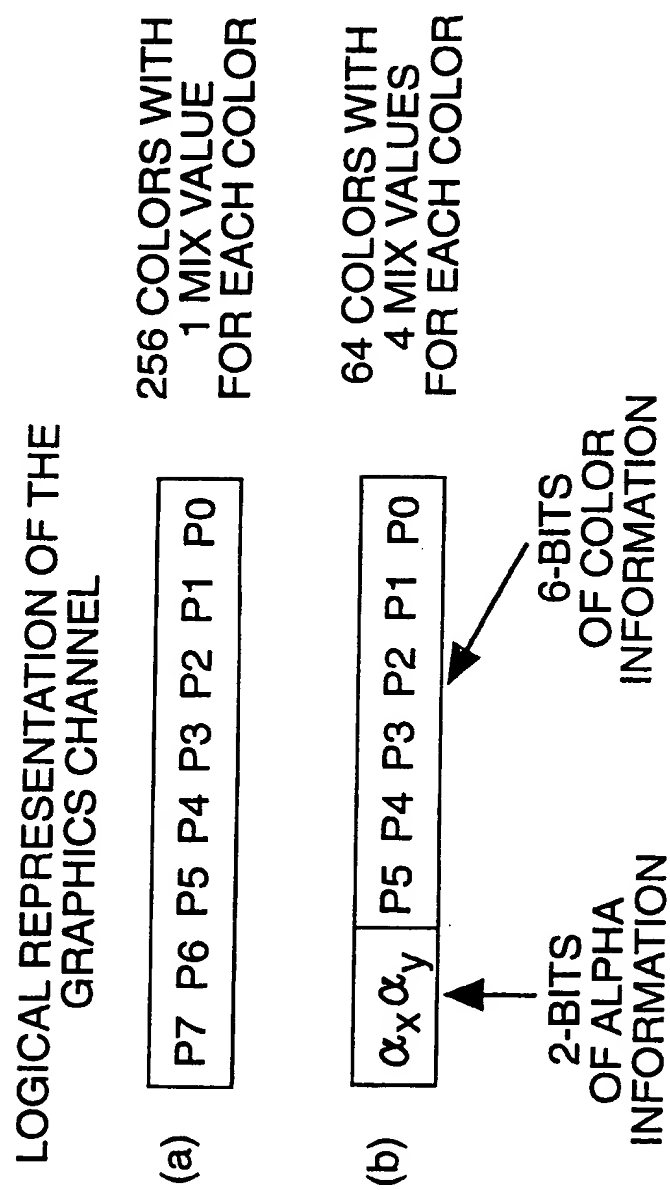
LOGICAL REPRESENTATION OF THE GRAPHICS CHANNEL
(a)
P7 P6 P5 P4 P3 P2 P1 P0
256 COLORS WITH 1 MIX VALUE FOR EACH COLOR
(b)
$\alpha_x \alpha_y$ P5 P4 P3 P2 P1 P0
64 COLORS WITH 4 MIX VALUES FOR EACH COLOR
2-BITS OF ALPHA INFORMATION
6-BITS OF COLOR INFORMATION

FIG. 8

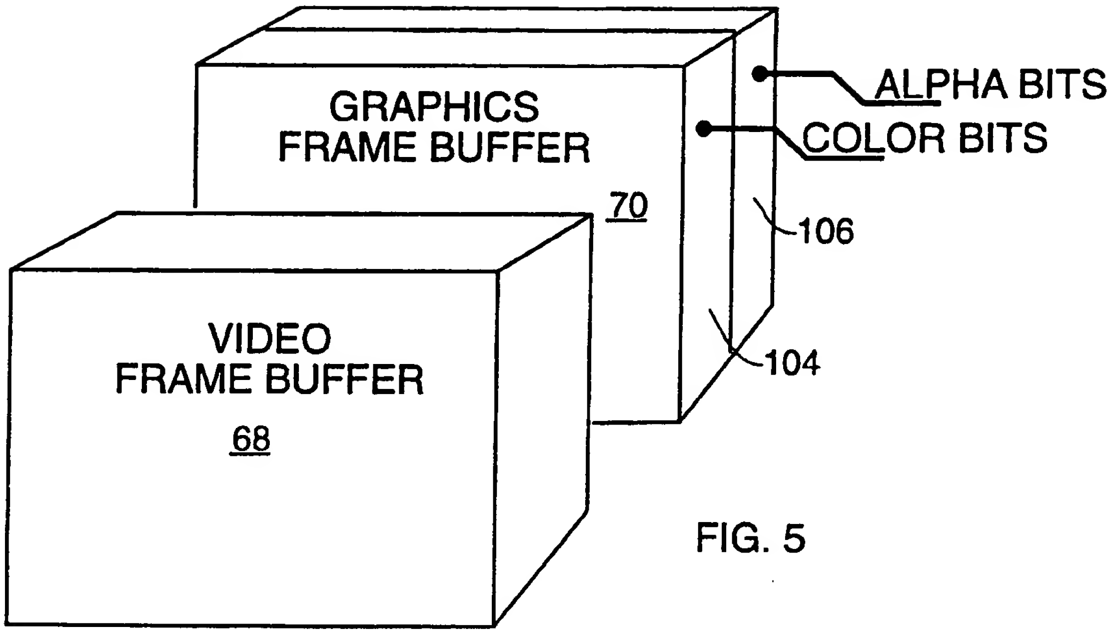

FIG. 5

8-BIT GRAPHICS CHANNEL			
COLOR ADDRESS BITS	ALPHA ADDRESS BITS	COLORS AVAILABLE	BLENDING LEVELS PER COLOR
8	0	256	1
7	1	128	2
6	2	64	4
5	3	32	8
4	4	16	16
3	5	8	32
2	6	4	64
1	7	2	128
0	8	1	256

FIG. 9

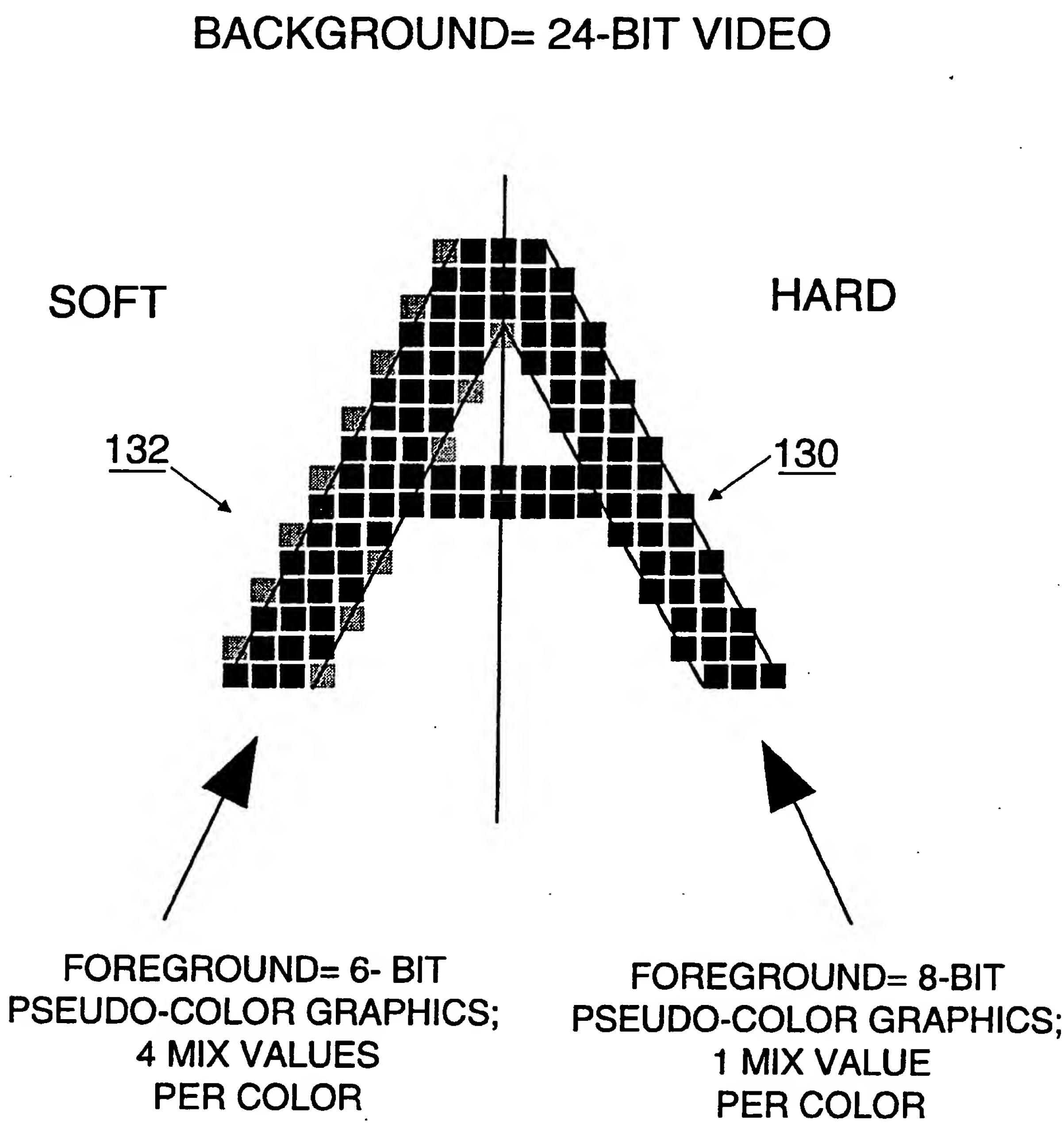
BACKGROUND= 24-BIT VIDEO
SOFT
HARD
132
130
FOREGROUND= 6- BIT
PSEUDO-COLOR GRAPHICS;
4 MIX VALUES
PER COLOR
FOREGROUND= 8-BIT
PSEUDO-COLOR GRAPHICS;
1 MIX VALUE
PER COLOR

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/07942

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :G09G 1/06; G09G 1/28
US CL :340/721, 723, 701, 703
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 340/721, 723, 701, 703

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US, A, 4,591,897 (Edelson) 27 May 1986 Fig.,4.	1-4, 11-23 ----------- 5-10
Y	US, A, 4,799,053 (Van Aken et al.) 17 January 1989, see the entire document.	5-10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 October 1993	NOV 16 1993

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	ALVIN OBERLEY
Facsimile No. NOT APPLICABLE	Telephone No. (703) 305-4709

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